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UTILITY PATENT APPLICATION TRANSMITTAL

(Only for new nonprovisional applications under 37 CFR 1.53(b))

Attorney Docket No.	4906.P012
First Inventor	David Carrel
Title	Method and Apparatus for Combining Packets Having Different Protocol Encapsulations Within a Circuit
Express Mail Label No.	EL485757443US

APPLICATION ELEMENTS

See MPEP chapter 600 concerning utility patent application contents.

1. [X] Fee Transmittal Form (e.g., PTO/SB/17) *(Submit an original and a duplicate for fee processing)*
2. [ ] Applicant claims small entity status. See 37 CFR 1.27.
3. [X] Specification [*Total Pages* 23] *(preferred arrangement set forth below)*
   - Descriptive title of the invention
   - Cross Reference to Related Applications
   - Statement Regarding Fed sponsored R & D
   - Reference to sequence listing, a table, or a computer program listing appendix
   - Background of the Invention
   - Brief Summary of the Invention
   - Brief Description of the Drawings *(if filed)*
   - Detailed Description
   - Claim(s)
   - Abstract of the Disclosure
4. [X] Drawing(s) *(35 U.S.C. 113)* [*Total Sheets* 6]
5. Oath or Declaration (unexecuted) [*Total Pages* 5]
   a. [ ] Newly executed (original or copy)
   b. [ ] Copy from a prior application (37 CFR 1.63 (d)) *(for continuation/divisional with Box 17 completed)*
      i. [ ] DELETION OF INVENTOR(S) Signed statement attached deleting inventor(s) named in the prior application, see 37 CFR 1.63(d)(2) and 1.33(b).
6. [ ] Application Data Sheet. See 37 CFR 1.76

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7. [ ] CD-ROM or CD-R in duplicate, large table or Computer Program (*Appendix*)
8. Nucleotide and/or Amino Acid Sequence Submission (*if applicable, all necessary*)
   a. [ ] Computer Readable Form (CRF)
   b. Specification Sequence Listing on:
      i. [ ] CD-ROM or CD-R (2 copies); or
      ii. [ ] paper
   c. [ ] Statements verifying identity of above copies

ACCOMPANYING APPLICATION PARTS

9. [ ] Assignment Papers (cover sheet & document(s))
10. [ ] 37 CFR 3.73(b) Statement *(when there is an assignee)* [ ] Power of Attorney
11. [ ] English Translation Document *(if applicable)*
12. [ ] Information Disclosure Statement (IDS)/PTO-1449 [ ] Copies of IDS Citations
13. [ ] Preliminary Amendment
14. [X] Return Receipt Postcard (MPEP 503) *(Should be specifically itemized)*
15. [ ] Certified Copy of Priority Document(s) *(if foreign priority is claimed)*
16. [ ] Other: .....

17. If a CONTINUING APPLICATION, *check appropriate box, and supply the requisite information below and in a preliminary amendment, or in an Application Data Sheet under 37 CFR 1.76:*

[ ] Continuation [ ] Divisional [ ] Continuation-in-part (CIP) of prior application No.: _____ / _____

Prior application information. *Examiner* _____ *Group / Art Unit.* _____

For CONTINUATION OR DIVISIONAL APPS only: The entire disclosure of the prior application, from which an oath or declaration is supplied under Box 5b, is considered a part of the disclosure of the accompanying continuation or divisional application and is hereby incorporated by reference. The incorporation can only be relied upon when a portion has been inadvertently omitted from the submitted application parts.

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FEE TRANSMITTAL for FY 2001

Patent fees are subject to annual revision.

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Complete if Known	
Application Number	Not yet assigned
Filing Date	Herewith
First Named Inventor	David Carrel
Examiner Name	Not yet assigned
Group Art Unit	Not yet assigned
Attorney Docket No.	4906.P012

METHOD OF PAYMENT

1. [X] The Commissioner is hereby authorized to charge indicated fees and credit any overpayments to:
   - Deposit Account Number: 02-2666
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   - [X] Charge Any Additional Fee Required Under 37 CFR 1.16 and 1.17
   - [ ] Applicant claims small entity status. See 37 CFR 1.27
2. [X] **Payment Enclosed:** [X] Check [ ] Credit card [ ] Money Order [ ] Other

FEE CALCULATION

1. BASIC FILING FEE

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
101	710	201	355	Utility filing fee	710
106	320	206	160	Design filing fee	
107	490	207	245	Plant filing fee	
108	710	208	355	Reissue filing fee	
114	150	214	75	Provisional filing fee	

SUBTOTAL (1) ($) 710

2. EXTRA CLAIM FEES

		Extra Claims		Fee from below	Fee Paid
Total Claims	32	-20** = 12	X	18	=216
Independent Claims	7	- 3** = 4	X	80	=320
Multiple Dependent					=

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description
103	18	203	9	Claims in excess of 20
102	80	202	40	Independent claims in excess of 3
104	270	204	135	Multiple dependent claim, if not paid
109	80	209	40	** Reissue independent claims over original patent
110	18	210	9	** Reissue claims in excess of 20 and over original patent

SUBTOTAL (2) ($) 536

**or number previously paid, if greater; For Reissues, see above

FEE CALCULATION (continued)

3. ADDITIONAL FEES

Large Entity Fee Code	Large Entity Fee ($)	Small Entity Fee Code	Small Entity Fee ($)	Fee Description	Fee Paid
105	130	205	65	Surcharge - late filing fee or oath	
127	50	227	25	Surcharge - late provisional filing fee or cover sheet	
139	130	139	130	Non-English specification	
147	2,520	147	2,520	For filing a request for *ex parte* reexamination	
112	920*	112	920*	Requesting publication of SIR prior to Examiner action	
113	1,840*	113	1,840*	Requesting publication of SIR after Examiner action	
115	110	215	55	Extension for reply within first month	
116	390	216	195	Extension for reply within second month	
117	890	217	445	Extension for reply within third month	
118	1,390	218	695	Extension for reply within fourth month	
128	1,890	228	945	Extension for reply within fifth month	
119	310	219	155	Notice of Appeal	
120	310	220	155	Filing a brief in support of an appeal	
121	270	221	135	Request for oral hearing	
138	1,510	138	1,510	Petition to institute a public use proceeding	
140	110	240	55	Petition to revive - unavoidable	
141	1,240	241	620	Petition to revive - unintentional	
142	1,240	242	620	Utility issue fee (or reissue)	
143	440	243	220	Design issue fee	
144	600	244	300	Plant issue fee	
122	130	122	130	Petitions to the Commissioner	
123	50	123	50	Petitions related to provisional applications	
126	240	126	240	Submission of Information Disclosure Stmt	
581	40	581	40	Recording each patent assignment per property (times number of properties)	
146	710	246	355	Filing a submission after final rejection (37 CFR § 1.129(a))	
149	710	249	355	For each additional invention to be examined (37 CFR § 1 129(b))	
179	710	279	355	Request for Continued Examination (RCE)	
169	900	169	900	Request for expedited examination of a design application	

Other fee (specify) _____

* Reduced by Basic Filing Fee Paid

SUBTOTAL (3) ($)

SUBMITTED BY

				Complete (if applicable)	
Name (Print/Type)	Gregg A. Peacock	Registration No. (Attorney/Agent)	45,001	Telephone	512-330-0844
Signature				Date	10-27-01

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UNITED STATES PATENT APPLICATION

FOR

METHOD AND APPARATUS FOR COMBINING PACKETS HAVING DIFFERENT PROTOCOL ENCAPSULATIONS WITHIN A CIRCUIT

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Attorney's Docket No. 004906.P012

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27 OCTOBER 2000
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METHOD AND APPARATUS FOR COMBINING PACKETS HAVING DIFFERENT PROTOCOL ENCAPSULATIONS WITHIN A CIRCUIT

FIELD OF THE INVENTION

The invention relates to the field of telecommunications. More specifically, the invention relates to a method and apparatus for combining packets having different protocol encapsulations within a circuit.

BACKGROUND OF THE INVENTION

With the advent of the Internet and the World Wide Web (WWW), the need for connectivity to and across different networks has become increasingly important. This increased need for connectivity translates into a need for a number of different network elements for the passing of the data traffic. These network elements can include routers, cables, hubs, relays, switches, etc., to carry communications between and among different networks. An increasing number of network elements have been deployed to support increasing network traffic; however, advancements in network technology have also been necessary to support the explosion in network traffic.

Such network elements assume multiple tasks such as terminating network connections, switching, routing and access functions. These network elements have been developed to support the vast and growing number of subscribers communicating across networks and across the Internet. Network elements have advanced from serving hundreds to serving thousands of subscribers, and now to hundreds of thousands of subscribers. Moreover, these network elements are configured to support a variety of communication protocols employed by the multitude of subscribers. Examples of these

supported communication protocols may include Asynchronous Transfer Mode (ATM) and Frame Relay. In addition, data transmitted by these network elements can be in stacks of protocols. For example, a subscriber may send data that is a Point-to-Point Protocol over Ethernet, which is over ATM. Accordingly, the circuits connecting to a network element is configured for the type of traffic that is being transmitted.

Moreover, such a need for network connectivity is no longer limited to a business setting. In particular, residential consumers are not only wanting connectivity for computing devices in their homes but also connectivity that allows for higher speed data transmission. The current array of choices for residential consumers is continuing to increase. For example, connectivity can include lower-speed connections at different rates, such as 56 kilobits/second, by employing a Plain Old Telephone Service (POTS) line from the residence. Other choices for connection, which are at higher speeds, into the Internet can include Integrated Services Digital Network (ISDN), Digital Subscribe Line (DSL) service, both over a POTS line, and cable modem service over a RF cable line.

Current networking capabilities are limited in how the data is transmitted through such connections. Typically, residential homes connect to the Internet through a network element using Internet Protocol (IP) packets that are encapsulated in Ethernet and/or Asynchronous Transfer Mode (ATM) for the transmission of data between the residential home and the network element connecting into the Internet. However, some residential homes can also connect to the Internet through a network element using IP packets that are encapsulated in a Point-to-Point Protocol (PPP), Ethernet and/or ATM for the transmission of data between the residential home and the Internet. The employment of Point-to-Point Protocol (PPP) over Ethernet (PPPoE) for the transmission of IP packets allows the network elements connected to the residential homes to associate a given computer within and among different homes that are communicating on a single line into the network elements with the different IP packets being received. In particular, the

PPPoE protocol includes identification of the source of the data being transmitted into a network element. However, not all computing devices in residential homes incorporate the PPPoE protocol into their communication with network elements connected thereto. In particular, certain software on such computing devices have not incorporated the functionality to handle the PPPoE encapsulation of the IP packets.

SUMMARY OF THE INVENTION

A method and apparatus for combining data packets having different protocol encapsulations within a circuit are described. In one embodiment, a method includes receiving a number of data packets on a real circuit and a number of virtual circuits. The number of virtual circuits are within the real circuit. Additionally, the number of data packets on the real circuit have a first protocol encapsulation, and the number of data packets on the number of virtual circuits have a second protocol encapsulation. The method also includes deencapsulating the number of data packets having the first protocol encapsulation. Moreover, the number of data packets having the second protocol encapsulation are deencapsulated. The method also includes forwarding the number of data packets having the first protocol encapsulation and the second protocol encapsulation based on an address stored in the number of data packets.

Additionally, in an embodiment, a method includes receiving a number of Internet Protocol (IP) packets over Ethernet on a real circuit. Each IP packet over Ethernet has an Ethernet header and an IP address. The method also includes removing the Ethernet header from the number of IP packets. Moreover, a number of IP packets within a Point-to-Point Protocol (PPP) over Ethernet are received on at least one virtual circuit. Each of the number of IP packets within the PPP over Ethernet includes a PPP header, an Ethernet header and an IP address. Additionally, the at least one virtual circuit runs

within the real circuit. The method also includes removing the PPP header from the number of IP packets within the PPP over Ethernet and removing the Ethernet header from the number of IP packets within the PPP over Ethernet. The number of IP packets over Ethernet and the number of IP packets within PPP over Ethernet are forwarded based on the IP address.

Moreover, in one embodiment, a network element includes a number of input/output (I/O) cards coupled to a number of real circuits. Each of the number of real circuits may include at least one virtual circuit. Additionally, the number of line cards receive a number of Internet Protocol (IP) packets over Ethernet on the real circuit and receive a number of IP packets within a Point-to-Point Protocol (PPP) over Ethernet session. The network element also includes a forwarding card having an IP address table. The forwarding card receives the number of IP packets from the number of I/O cards and forwards the IP packets based on the IP address table.

BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the invention may be best understood by referring to the following description and accompanying drawings which illustrate such embodiments. In the drawings:

Figure 1 is block diagram illustrating a system that incorporates embodiments of the present invention;

Figure 2 illustrates a block diagram of network element 104, according to embodiments of the present invention;

Figure 3 is a flowchart illustrating a method of processing data packets of differing protocols on a single real circuit, according to embodiments of the present invention;

Figure 4 illustrates a more detail diagram of physical transmission line 108 that includes a number of virtual circuits, according to embodiments of the present invention;

Figures 5a-5b are block diagrams illustrating one embodiment of the different protocol encapsulations of a data packet using different protocols, according to embodiments of the present invention; and

Figure 6 is block diagram illustrating another system embodiment that incorporates embodiments of the present invention.

DETAILED DESCRIPTION

A method and apparatus for combining data packets having different protocol encapsulations within a circuit are described. In the following description, for purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be evident, however, to one skilled in the art that the present invention may be practiced without these specific details.

Figure 1 is block diagram illustrating a system that incorporates embodiments of the present invention. Figure 1 includes residential homes 102a-i, physical transmission line 108, network element 104 and network 106. Residential homes 102*a-i* can include one to any number of homes. Moreover, as shown, residential homes 102a-i are coupled to network element 104 through physical transmission line 108. In an embodiment, residential homes 102a-i can include one to a number of computing devices, such as desktop computer, notebook computer, Personal Digital Assistants (PDAs), that are coupled to physical transmission line 108.

In one embodiment, network 106 is a local area network (LAN). In another embodiment, network 106 is a wide area network (WAN). In one such embodiment, network 106 is the Internet. Further, network 106 can be a combination of different networks that provide communication between different network elements and/or other

computing devices, such as a client computer, coupled thereto.

In an embodiment, physical transmission line 108 is defined as a real circuit. In the description herein, the term "real circuit" is described in terms of a physical transmission line. However, embodiments of the present invention are not so limited. For example, a real circuit could include a permanent virtual circuit, as is known in the art. Figure 1 only shows one physical transmission line coming into network element 104. However, this is for the sake of clarity and not by way of limitation, as a number of different physical transmission lines can be coupled into network element 104. Additionally, each of this different physical transmission lines can be coupled to one to a number of different computing devices from a number of different residential homes into network element 104. Further, Figure 1 illustrates a single physical transmission line connecting a number of homes into network element 104. However, embodiments of the present invention are not so limited. In particular, in an embodiment, a physical transmission line can couple one house to network element 104.

In an embodiment, physical transmission line 108 could be a Plain Old Telephone Service (POTS) line. In one such embodiment, physical transmission line 108 could be a Digital Subscriber Line (DSL). In another embodiment, physical transmission line 108 could be a cable line transmitting the data packets over an RF cable signal. The above-described embodiments of physical transmission line 108 are by way of example and not by way of limitation, as any other type of physical line capable of carrying data packets can be incorporated into embodiments of the present invention. For example, physical transmission line 108 could be a fiber optics cable carrying the data traffic over an optical signal.

Additionally, as shown, Figure 1 includes residential homes 102a-i coupled to network element 104. However, embodiments of the present invention are not so limited, as any other type of building that includes one to a number of computing devices, as described herein, can be incorporated into embodiments of the present invention. For

example, computing devices of businesses can be coupled to network element 104.

Figure 2 illustrates a block diagram of network element 104, according to embodiments of the present invention. As shown, network element 104 includes input/output (I/O) cards 202-208. Network element 104 is not limited to the number of I/O cards shown in Figure 2, as network element 104 can include any of a number of different I/O cards. Network element 104 also includes control card 210 and forwarding card 212.

In an embodiment, each of I/O cards 202-208, control card 210 and forwarding card 212 can include a processor and memory. Each of I/O cards 202-208, control card 210 and forwarding card 212 are coupled to system buses. Control card 210 performs control, system configuration and management tasks for network element 104. For example, if forwarding card 212 needs to be updated with a new Internet Protocol (IP) address table, such data is received by control card 210 and transmitted to forwarding card 212.

Moreover, forwarding card 212 provides for buffering, packet processing and forwarding of data packets being received by I/O cards 202-208. In particular, I/O 202-208 cards can be coupled to a number of data transmission lines, such as physical transmission line 108 of Figure 1, which are coupled to other network elements and/or computing devices, as shown in Figure 1. Accordingly, I/O cards 202-208 receive and transmit data traffic from and to data transmission lines coupled thereto. Such data traffic is transmitted to forwarding card 212, where this traffic can be buffered, processed and/or forwarded to other I/O cards within network element 104, as will be described in more detail below.

The embodiment of network element 104 is by way of example and not by way of limitation, as network elements having other architectural configurations can incorporate embodiments of the present invention. Examples of other network elements that include incorporate embodiments of the present invention could have multiple forwarding cards

or have a single line card incorporating the functionality of both the forwarding and the controlling. Moreover, a network element having the forwarding functionality distributed across the I/O cards could incorporate embodiments of the present invention.

Embodiments of operation of network element 104 will now be described in conjunction with Figure 3. In particular, **Figure 3** is a flowchart illustrating a method of processing data packets of differing protocols on a single real circuit, according to embodiments of the present invention. Method 300 of Figure 3 is described in terms of a single physical transmission line coupled to I/O card 202. Operations of method 300 are applicable to any I/O card within network element 104, which is coupled to a physical transmission line.

Method 300 of Figure 3 commences with the receipt of a number of data packets over physical transmission line 108 by I/O card 202, at process block 302. In an embodiment, the data packets are based on different protocols. In one such embodiment, the data packets are based on two different protocols, such that a first protocol is transmitted on physical transmission line 108 (i.e., the real circuit), while a second set of data packets based on a second protocol is transmitted on a number of virtual circuits within the real circuit. In particular, **Figure 4** illustrates a more detail diagram of physical transmission line 108 that includes a number of virtual circuits, according to embodiments of the present invention. Physical transmission line 108 acts as real circuit 402. Additionally, physical transmission line 108 includes virtual circuits 404-410. The number of virtual circuit illustrated in Figure 4 are by way of example and not by way of limitation, as physical transmission line 108 can include a lesser or greater number of virtual circuits. In one embodiment, the number of virtual circuits that can be included in physical transmission line 108 is 65,535.

In one embodiment, a virtual circuit is created upon the initiation by a computing device coupled to physical transmission line 108. In particular, such a computing device executes a software application that initiates and negotiates a PPPoE session with

network element 104. Accordingly, upon receiving this initiation request, network element 104 establishes the PPPoE session and creates the virtual circuit. Accordingly, each data packet received and transmitted from this computing device during this PPPoE session includes a PPPoE session identification to enable network element 104 to associate a given data packet with the particular PPPoE session, thereby creating a virtual circuit between this computing device and network element 104.

Figures 5a-5b are block diagrams illustrating one embodiment of the different protocol encapsulations of a data packet using different protocols, according to embodiments of the present invention. Figures 5a-5b illustrate a protocol encapsulation wherein the given data packet is an IP packet, which is shown as block 506. Additionally, Figure 5a illustrates the encapsulation of IP packet 506 within Ethernet layer 504, which is termed IP over Ethernet (IPoE). As shown, IP packet 506 can be further encapsulated within ATM layer 502. Figure 5b illustrates the encapsulation of IP packet 506 within PPP layer 508 and PPPoE layer 510. Further, IP packet 506 is encapsulated within Ethernet layer 504, which is termed PPP over Ethernet (PPPoE). As shown, IP packet 506 can be further encapsulated within ATM layer 502.

The protocol encapsulation illustrated in Figures 5a-5b are by way of example and not by way of limitation, as other types of data packets employing other types of protocols can used within embodiments of the present invention. For example, in an embodiment, the data packets can be encapsulated within a Frame Relay protocol layer, instead of the ATM protocol layer.

In one embodiment, real circuit 402 (i.e., physical transmission line 108) transmits IP packets over Ethernet. In one such embodiment, these IP packets are further encapsulated within an ATM protocol layer, as illustrated by Figure 5a. In an embodiment, virtual circuits 404-410 are transmitting IP packets within PPP over Ethernet. In one such embodiment, these IP packets are further encapsulated within an ATM protocol layer, as illustrated by Figure 5b.

Moreover, in an embodiment, a given virtual circuit is associated with a given PPPoE session between a computing device and network element 104. Returning to Figure 1, one to a number of computing devices can be included in each of residential homes 102a-i, such that these computing devices can be coupled to network element 104 through a PPPoE session, thereby transmitting the IP packets using the encapsulation illustrated by Figure 5b. In one embodiment, a given virtual circuit is generated upon the creation of a PPPoE session between a given computing device and network element 104, as described above.

The encapsulation of IP packets within PPPoE enables network element 104 to associate a given PPPoE session on a given computing device with a set of data traffic being sent. Accordingly, network element 104 can perform a finer grain of accounting such that network element 104 is able to determine how many given IP packets are being received from and transmitted to network element 104 for a given PPPoE session for a given computing device. In turn, network element 104 could limit the data rate for a given computing device or other type of policing of the data bandwidth of physical transmission line 108 based on the tracking of these PPPoE sessions.

Conversely, a number of these computing devices may not have the functionality to communicate to network element 104 using PPPoE because of the software running thereon. Accordingly, such computing devices can be coupled to network element 104 such that data traffic sent between the computing devices and network element 104 are employing IPoE, thereby transmitting the IP packets using the encapsulation illustrated by Figure 5a. Therefore, embodiments of the present invention allow for PPPoE and IPoE over a single real circuit by employing virtual circuits within the real circuit for the transmission of PPPoE data traffic.

Returning to method 300 of Figure 3, upon receipt of a given data packet, I/O card 202 of network element 104 removes the ATM header from the data packet, at process block 304. In other words the IP packet is deencapsulated from the ATM

protocol layer. Additionally, I/O card 202 determines whether the data packet is an IP packet encapsulated within PPP over Ethernet transmitted over a virtual circuit located within real circuit 402, at process decision block 306. In an embodiment, I/O card 202 determines whether the data packet is an IP packet encapsulated within PPP over Ethernet based on the Ethernet header. In particular, the Ethernet header includes data that identifies what the Ethernet layer is encapsulating.

Upon determining that the data packet is an IP packet encapsulated within PPP over Ethernet transmitted over a virtual circuit, I/O card 202 determines which of virtual circuits 404-410 that data packet was received from, at process block 308. In an embodiment, I/O card 202 determines which of virtual circuits 404-410 that the data packet was received from based on the Ethernet header and/or the PPP header. In particular, the Ethernet header and the PPPoE header can include data that identifies the virtual circuit that data packet was received from.

Additionally, I/O card 202 can perform accounting of the data packet, at process block 310. In an embodiment, I/O card 202 calculates the number of data packets that are received on a given virtual circuit. Accordingly, I/O card 202 can limit the amount of traffic that can be transmitted on a given virtual circuit. Additionally, such accounting enables I/O card 202 to perform sanity and/or security checking to ensure that the data being received is accurate. I/O card 202 also removes the Ethernet header from the data packet, at process block 312. Moreover, I/O card 202 removes the PPPoE header and PPP header from the data packet, at process block 314. In other words the IP packet is deencapsulated from the Ethernet and PPP protocol layers.

This IP packet is then forwarded to forwarding card 212 of network element 104. Accordingly, forwarding card 212 forwards the IP packet to one of I/O cards 202-208 based on the IP address contained in the IP packet, at process block 318. In an embodiment, forwarding card 212 includes an IP address table, which serves as a translation for the IP address. In particular, this IP address table associates a given IP

address with one of the ports of one of I/O cards 202-208, as different ports are coupled to other network elements within network 106 and/or other computing devices coupled to physical transmission line 108.

Upon determining that the data packet is not IP packet over PPP over Ethernet on a virtual circuit, I/O card 202 removes the Ethernet header from the IP packet, at process block 316. I/O card 202 then forwards the IP packet to one of I/O cards 202-208 based on the IP address contained in the IP packet, at process block 318, as described above.

Method 300 is described in terms of an ATM protocol layer encapsulating IP packet within the Ethernet protocol layer. However, embodiments of the present invention are not so limited, as the IP packet could be just encapsulated within the Ethernet protocol layer. For example, the computing device and network element 104 could be coupled together to receive Ethernet-based IP packets, independent of an additional protocol layer.

Moreover, embodiments of the present invention are not limited to the network and system configuration illustrated in Figure 1. In particular, **Figure 6** is block diagram illustrating another system embodiment that incorporates embodiments of the present invention. As shown, in addition to the elements described above in conjunction with the system of Figure 1, Figure 6 includes network element 602 that is located between residential houses 102*a-i* and network element 104. Physical transmission line 604, which is similar to physical transmission line 108, couples residential houses 102a-i to network element 602. Further, network element 602 is coupled to network element 104 through physical transmission line 606. In an embodiment, physical transmission line 606 is an Ethernet-based line. In operation, the different IP packets from the real circuit and virtual circuits within physical transmission line 604 are transmitted to network element 602. Network element 602 then transports these data packets within the real circuit and the virtual circuits through physical transmission line 606, as described above.

Additionally, embodiments of the present invention could be incorporated into

other network configurations wherein network element 104 is communicating with another network element, such that the communication is Ethernet-based. An example of such a network element could be an Ethernet bridge. Moreover, embodiments of the present invention can incorporate other types of IP packets into the virtual circuits within a given real circuit. In one such embodiment, the virtual circuits are based on the Ethernet hardware address of a given computing device and not an IP packet that is encapsulated within PPP over Ethernet. In another embodiment, the virtual circuits could be based on the source IP address of the given IP packet. Accordingly, embodiments of the present invention can be incorporated into different system wherein network element 104 is able to receive a first type of data traffic on the real circuit and a second type of data traffic on a number of virtual circuits within the real circuit.

Moreover as described above, I/O cards 202-208, control card 210 and forwarding card 212 include both a processor and memory. Such memory includes a machine-readable medium on which is stored a set of instructions (i.e., software) embodying any one, or all, of the methodologies described herein. Software can reside, completely or at least partially, within such memory and/or within the processor. For the purposes of this specification, the term "machine-readable medium" shall be taken to include any mechanism that provides (i.e., stores and/or transmits) information in a form readable by a machine (e.g., a computer). For example, a machine-readable medium includes read only memory (ROM); random access memory (RAM); magnetic disk storage media; optical storage media; flash memory devices; electrical, optical, acoustical or other form of propagated signals (e.g., carrier waves, infrared signals, digital signals, etc.); etc.

Thus, a method and apparatus for combining data packets having different protocol encapsulations within a circuit have been described. Although the present invention has been described with reference to specific exemplary embodiments, it will be evident that various modifications and changes may be made to these embodiments without departing from the broader spirit and scope of the invention. For example,

embodiments of the present invention could provide for additional protocol encapsulation layers during the transmission of data packets. Accordingly, the specification and drawings are to be regarded in an illustrative rather than a restrictive sense.

CLAIMS

What is claimed is:

1. A method comprising:

receiving a number of data packets on a real circuit and a number of virtual circuits, wherein the number of virtual circuits are within the real circuit such that the number of data packets on the real circuit have a first protocol encapsulation and the number of data packets on the number of virtual circuits have a second protocol encapsulation;

deencapsulating the number of data packets having the first protocol encapsulation;

deencapsulating the number of data packets having the second protocol encapsulation; and

forwarding the number of data packets having the first protocol encapsulation and the second protocol encapsulation based on an address stored in the number of data packets.

2. The method of claim 1, wherein the number of data packets are Internet Protocol (IP) packets.

3. The method of claim 2, wherein the first protocol encapsulation is IP over Ethernet.

4. The method of claim 3, wherein the second protocol encapsulation is a Point-to-Point Protocol over Ethernet.

5. A method comprising:

receiving a number of Internet Protocol (IP) packets over Ethernet on a real circuit, each IP packet over Ethernet having an Ethernet header and an IP address;

removing the Ethernet header from the number of IP packets;

receiving a number of IP packets within a Point-to-Point Protocol (PPP) over Ethernet on at least one virtual circuit, wherein each of the number of IP packets within the PPP over Ethernet includes a PPP header, a PPP over Ethernet (PPPoE) header, an Ethernet header and an IP address, wherein the at least one virtual circuit runs within the real circuit;

removing the PPP header and the PPPoE header from the number of IP packets within the PPP over Ethernet;

removing the Ethernet header from the number of IP packets within the PPP over Ethernet; and

forwarding the number of IP packets over Ethernet and the number of IP packets within PPP over Ethernet based on the IP address.

6. The method of claim 5, wherein the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet are encapsulated in an Asynchronous Transfer Mode (ATM) protocol layer.

7. The method of claim 6, further comprising removing the ATM protocol layer from the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet.

8. The method of claim 5, further comprising calculating the number of IP packets within the PPP over Ethernet that are being received from the at least one virtual circuit.

9. The method of claim 8, further comprising performing rate limiting on the at least one virtual circuit based on the number of calculated IP packets within the PPP over Ethernet.

10. A method comprising:

receiving a number of different data packets over Ethernet on both a real circuit and a number of virtual circuits running within the real circuit;

recursively performing the following for each of the number of different data packets:

upon determining that a received data packet is an Internet Protocol (IP) packet over Ethernet on the real circuit, removing an Ethernet header from the received data packet and forwarding the IP packet based on an IP address stored in the IP packet; and

upon determining that a received data packet is an IP packet within a Point-to-Point Protocol (PPP) over Ethernet on one of the number of virtual circuits, removing an Ethernet header, a PPP header and a PPP over Ethernet (PPPoE) header from the data packet and forwarding the IP packet based on an IP address stored in the IP packet.

11. The method of claim 10, wherein the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet are encapsulated in an Asynchronous Transfer Mode (ATM) protocol layer.

12. The method of claim 11, further comprising removing the ATM protocol layer from the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet.

13. The method of claim 10, further comprising calculating the number of IP packets within the PPP over Ethernet that are being received from the at least one virtual circuit.

14. The method of claim 13, further comprising performing rate limiting on the at least one virtual circuit based on the number of calculated IP packets within the PPP over Ethernet.

15. A network element comprising:

a number of input/output (I/O) cards coupled to a number of real circuits, wherein each of the number of real circuits include at least one virtual circuit, the number of I/O cards to receive a number of Internet Protocol (IP) packets over Ethernet on the real circuit and to receive a number of IP packets within a Point-to-Point Protocol (PPP) over Ethernet on the at least one virtual circuit; and

a forwarding card having an IP address table, the forwarding card to receive the number of IP packets from the number of I/O cards and to forward the IP packets based on the IP address table.

16. The network element of claim 15, further comprising a control card having a database of configuration information, the configuration information used to configure the forwarding card and the number of I/O cards.

17. The network element of claim 15, wherein the number of I/O cards to determine the number of IP packets within the PPP over Ethernet that are being received from the at least one virtual circuit.

18. The network element of claim 15, wherein the number of I/O cards to perform rate limiting on the at least one virtual circuit based on the number of calculated IP packets within the PPP over Ethernet.

19. A machine-readable medium that provides instructions which, when executed by a machine, cause said machine to perform operations comprising:

receiving a number of data packets on a real circuit and a number of virtual circuits, wherein the number of virtual circuits are within the real circuit such that the number of data packets on the real circuit having a first protocol encapsulation and the number of data packets on the number of virtual circuits having a second protocol encapsulation;

deencapsulating the number of data packets having the first protocol encapsulation;

deencapsulating the number of data packets having the second protocol encapsulation; and

forwarding the number of data packets having the first protocol encapsulation and the second protocol encapsulation based on an address stored in the number of data packets.

20. The machine-readable medium of claim 19, wherein the number of data packets are Internet Protocol (IP) packets.

21. The machine-readable medium of claim 20, wherein the first protocol encapsulation is IP over Ethernet.

22. The machine-readable medium of claim 21, wherein the second protocol encapsulation is a Point-to-Point Protocol over Ethernet.

23. A machine-readable medium that provides instructions which, when executed by a machine, cause said machine to perform operations comprising:

receiving a number of Internet Protocol (IP) packets over Ethernet on a real circuit, each IP packet over Ethernet having an Ethernet header and an IP address;

removing the Ethernet header from the number of IP packets;

receiving a number IP packets within a Point-to-Point Protocol (PPP) over Ethernet on at least one virtual circuit, wherein each of the number of IP packets within the PPP over Ethernet includes a PPP header, a PPP over Ethernet (PPPoE) header, an Ethernet header and an IP address, wherein the at least one virtual circuit runs within the real circuit;

removing the PPP header and the PPPoE header from the number of IP packets within the PPP over Ethernet;

removing the Ethernet header from the number of IP packets within the PPP over Ethernet; and

forwarding the number of IP packets over Ethernet and the number of IP packets within PPP over Ethernet based on the IP address.

24. The machine-readable medium of claim 23, wherein the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet are encapsulated in an Asynchronous Transfer Mode (ATM) protocol layer.

25. The machine-readable medium of claim 24, further comprising removing the ATM protocol layer from the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet.

26. The machine-readable medium of claim 23, further comprising calculating the number of IP packets within the PPP over Ethernet that are being received from the at least one virtual circuit.

27. The machine-readable medium of claim 26, further comprising performing rate limiting on the at least one virtual circuit based on the number of calculated IP packets within the PPP over Ethernet.

28. A machine-readable medium that provides instructions which, when executed by a machine, cause said machine to perform operations comprising:

receiving a number of different data packets over Ethernet on both a real circuit and a number of virtual circuits running within the real circuit;

recursively performing the following for each of the number of different data packets:

upon determining that a received data packet is an Internet Protocol (IP) packet over Ethernet on the real circuit, removing an Ethernet header from the received data packet and forwarding the IP packet based on an IP address stored in the IP packet; and

upon determining that a received data packet is an IP packet within a Point-to-Point Protocol (PPP) over Ethernet on one of the number of virtual circuits, removing an Ethernet header, a PPP header and a PPP over Ethernet

(PPPoE) header from the data packet and forwarding the IP packet based on an IP address stored in the IP packet.

29. The machine-readable medium of claim 28, wherein the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet are encapsulated in an Asynchronous Transfer Mode (ATM) protocol layer.

30. The machine-readable medium of claim 29, further comprising removing the ATM protocol layer from the number of IP packets over Ethernet and the number of IP packets within the PPP over Ethernet.

31. The machine-readable medium of claim 28, further comprising calculating the number of IP packets within the PPP over Ethernet that are being received from the at least one virtual circuit.

32. The machine-readable medium of claim 31, further comprising performing rate limiting on the at least one virtual circuit based on the number of calculated IP packets within the PPP over Ethernet.

ABSTRACT OF THE DISCLOSURE

A method and apparatus for combining data packets having different protocol encapsulations within a circuit is described. In one embodiment, a method includes receiving a number of Internet Protocol (IP) packets over Ethernet on a real circuit. Each IP packet over Ethernet has an Ethernet header and an IP address. The method also includes removing the Ethernet header from the number of IP packets. Moreover, a number IP packets within a Point-to-Point Protocol (PPP) over Ethernet are received on at least one virtual circuit. Each of the number of IP packets within the PPP over Ethernet includes a PPP header, a PPP over Ethernet (PPPoE) header, an Ethernet header and an IP address. Additionally, the at least one virtual circuit runs within the real circuit. The method also includes removing the PPP header and the PPPoE header from the number of IP packets within the PPP over Ethernet and removing the Ethernet header from the number of IP packets within the PPP over Ethernet. The number of IP packets over Ethernet and the number of IP packets within PPP over Ethernet are forwarded based on the IP address.

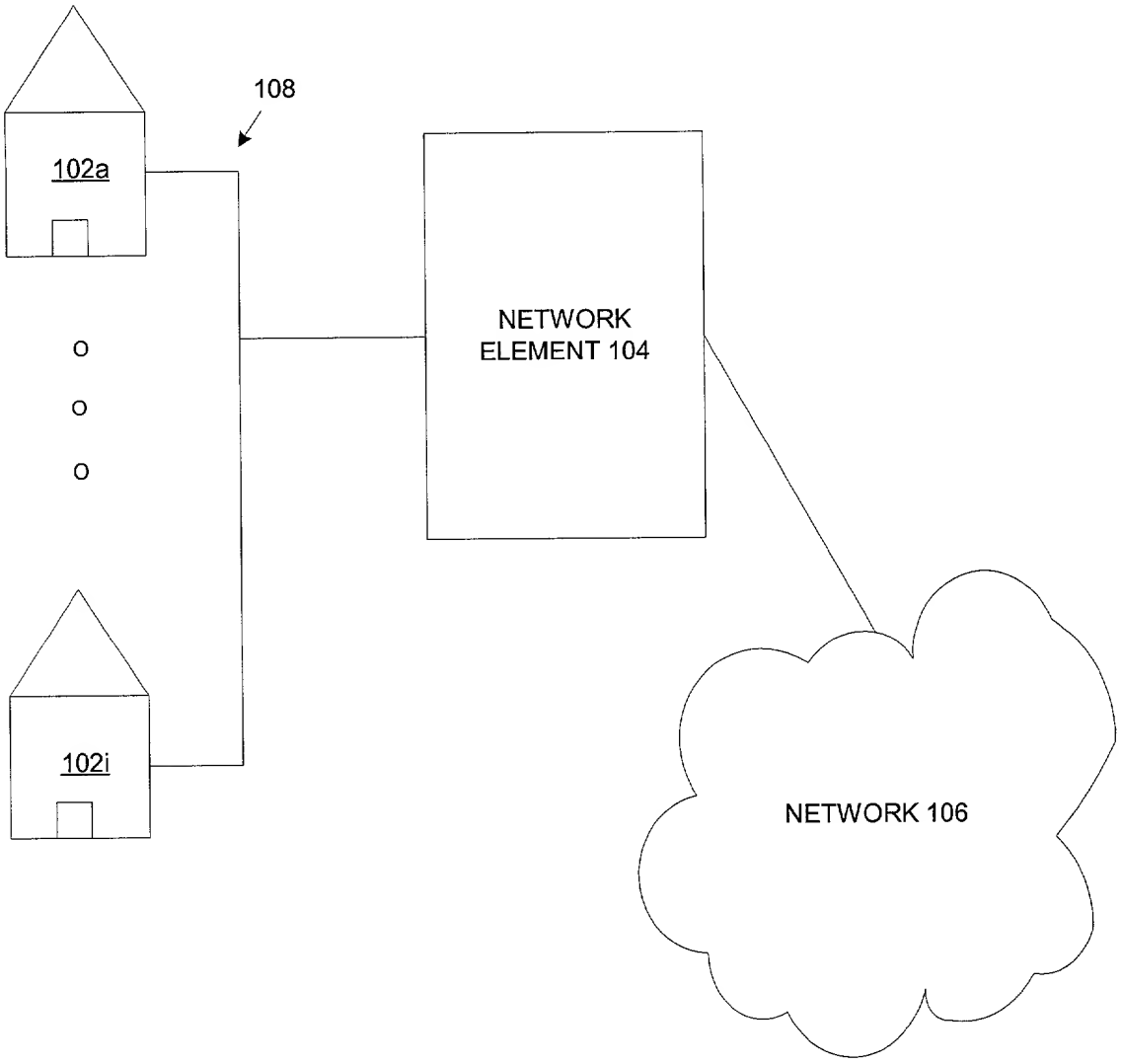

FIG. 1

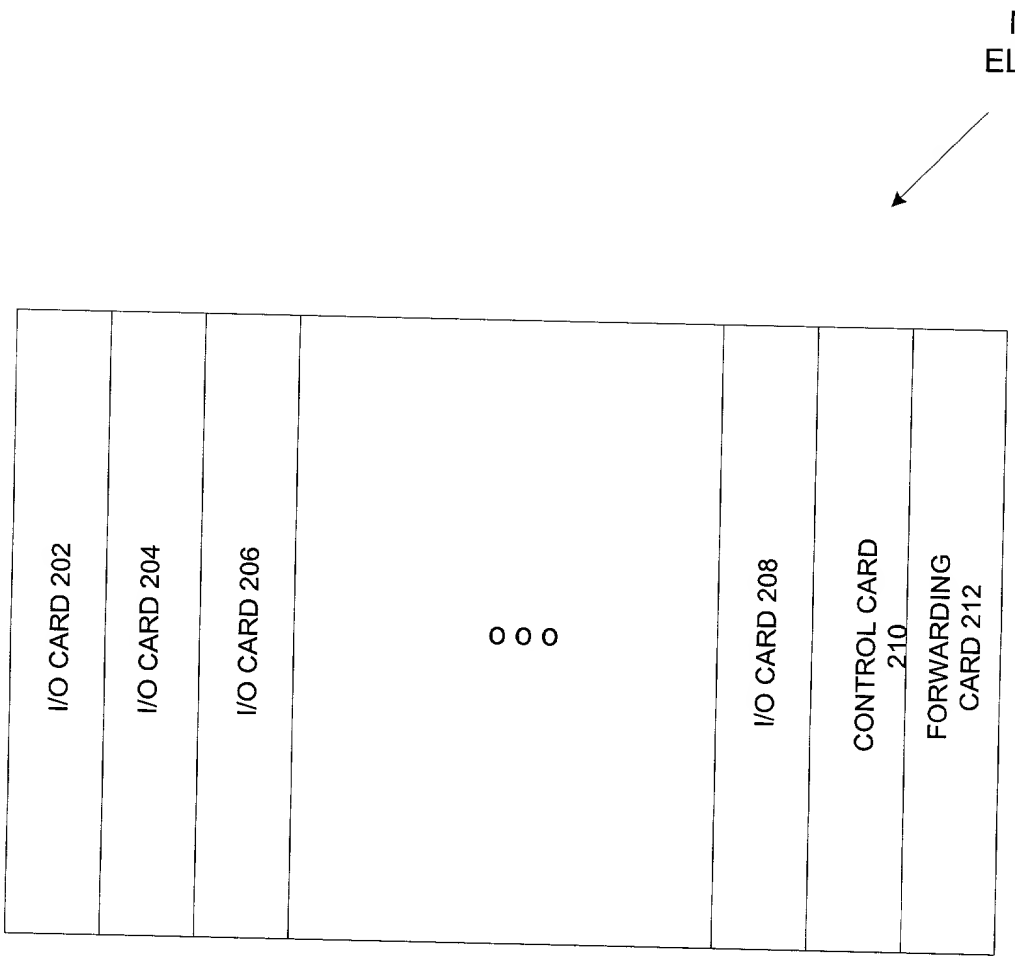
NETWORK
ELEMENT 104
I/O CARD 202
I/O CARD 204
I/O CARD 206
o o o
I/O CARD 208
CONTROL CARD
210
FORWARDING
CARD 212

FIG. 2

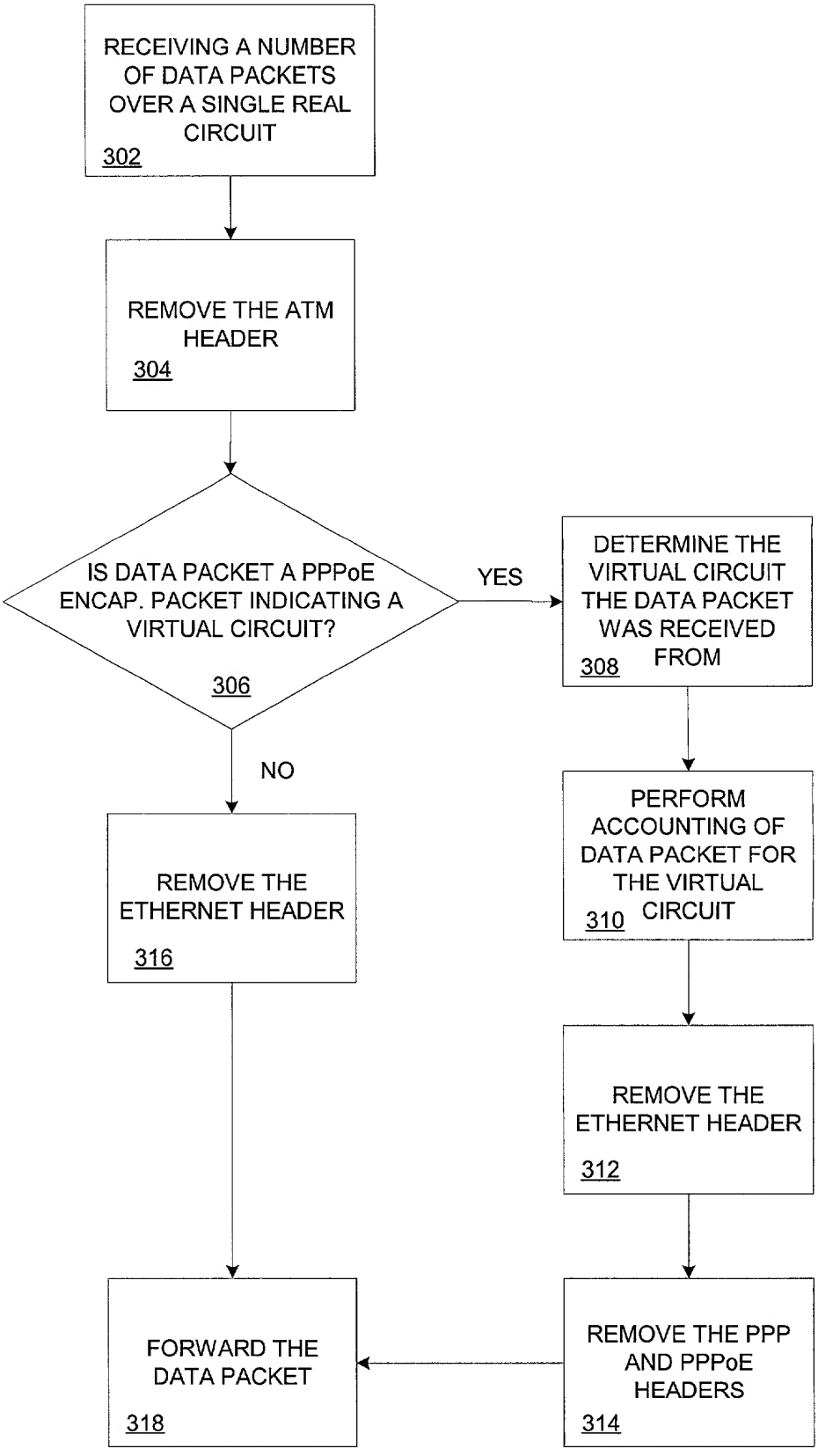
RECEIVING A NUMBER OF DATA PACKETS OVER A SINGLE REAL CIRCUIT
302
REMOVE THE ATM HEADER
304
IS DATA PACKET A PPPoE ENCAP. PACKET INDICATING A VIRTUAL CIRCUIT?
306
YES
NO
DETERMINE THE VIRTUAL CIRCUIT THE DATA PACKET WAS RECEIVED FROM
308
PERFORM ACCOUNTING OF DATA PACKET FOR THE VIRTUAL CIRCUIT
310
REMOVE THE ETHERNET HEADER
312
REMOVE THE PPP AND PPPoE HEADERS
314
REMOVE THE ETHERNET HEADER
316
FORWARD THE DATA PACKET
318

FIG. 3

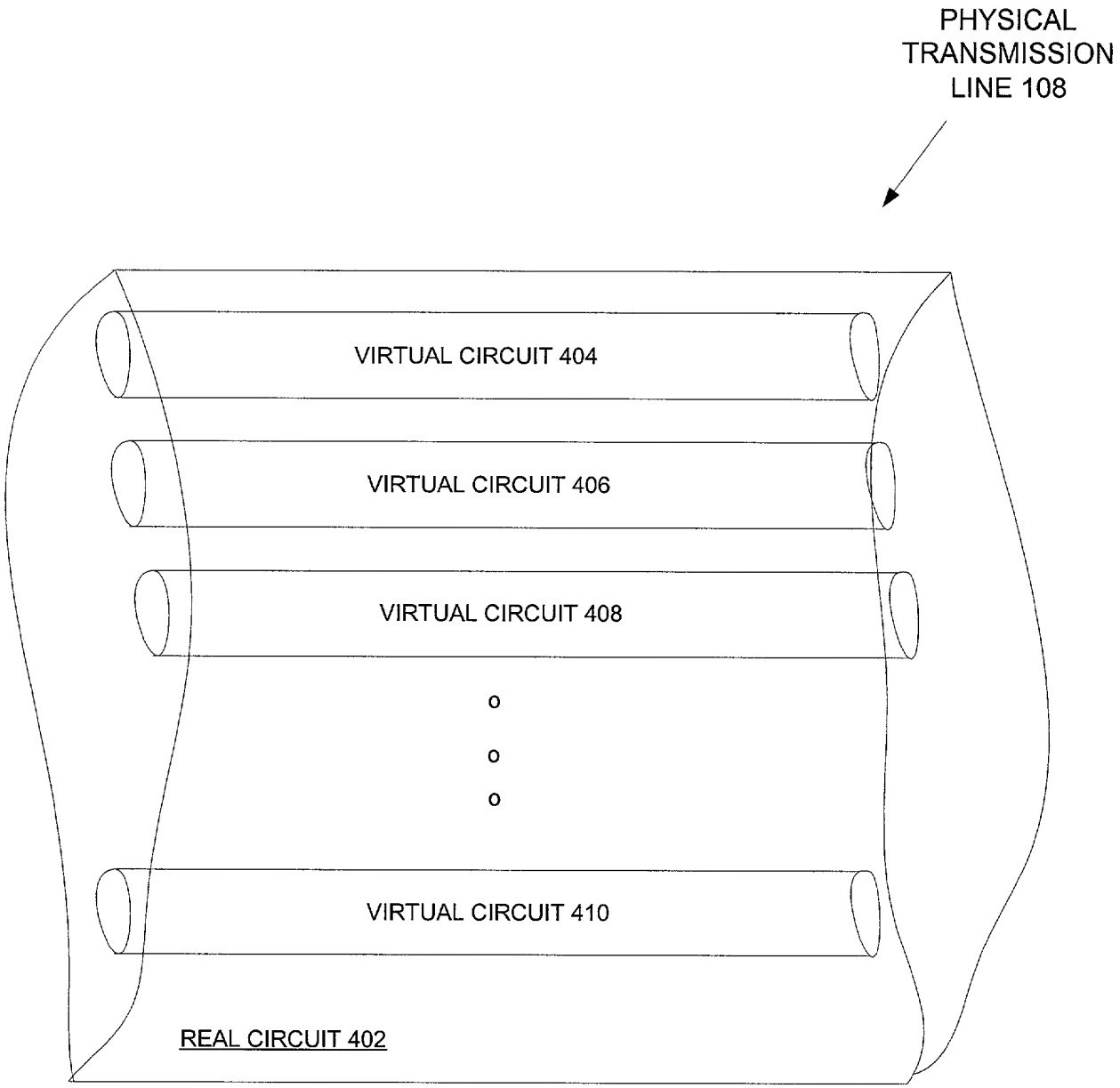
PHYSICAL
TRANSMISSION
LINE 108
VIRTUAL CIRCUIT 404
VIRTUAL CIRCUIT 406
VIRTUAL CIRCUIT 408
o
o
o
VIRTUAL CIRCUIT 410
REAL CIRCUIT 402

FIG. 4

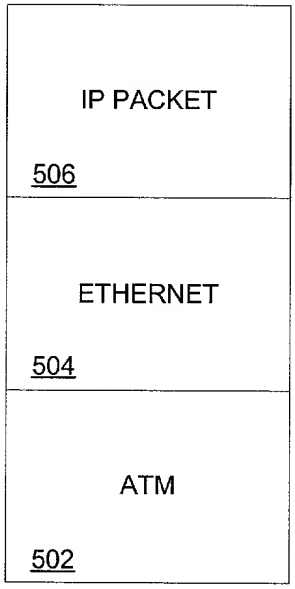
IP PACKET
506
ETHERNET
504
ATM
502

FIG. 5a

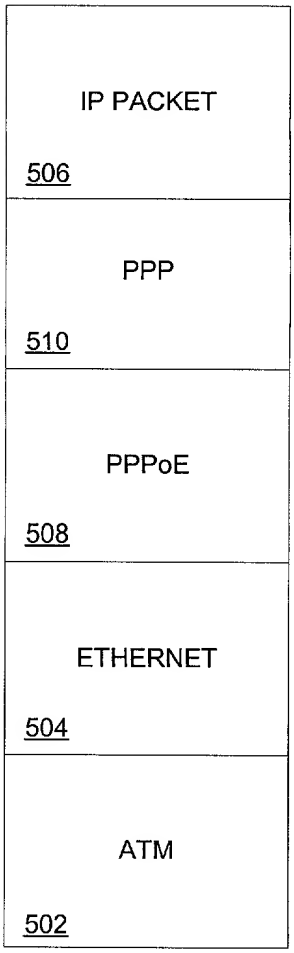
IP PACKET
506
PPP
510
PPPoE
508
ETHERNET
504
ATM
502

FIG. 5b

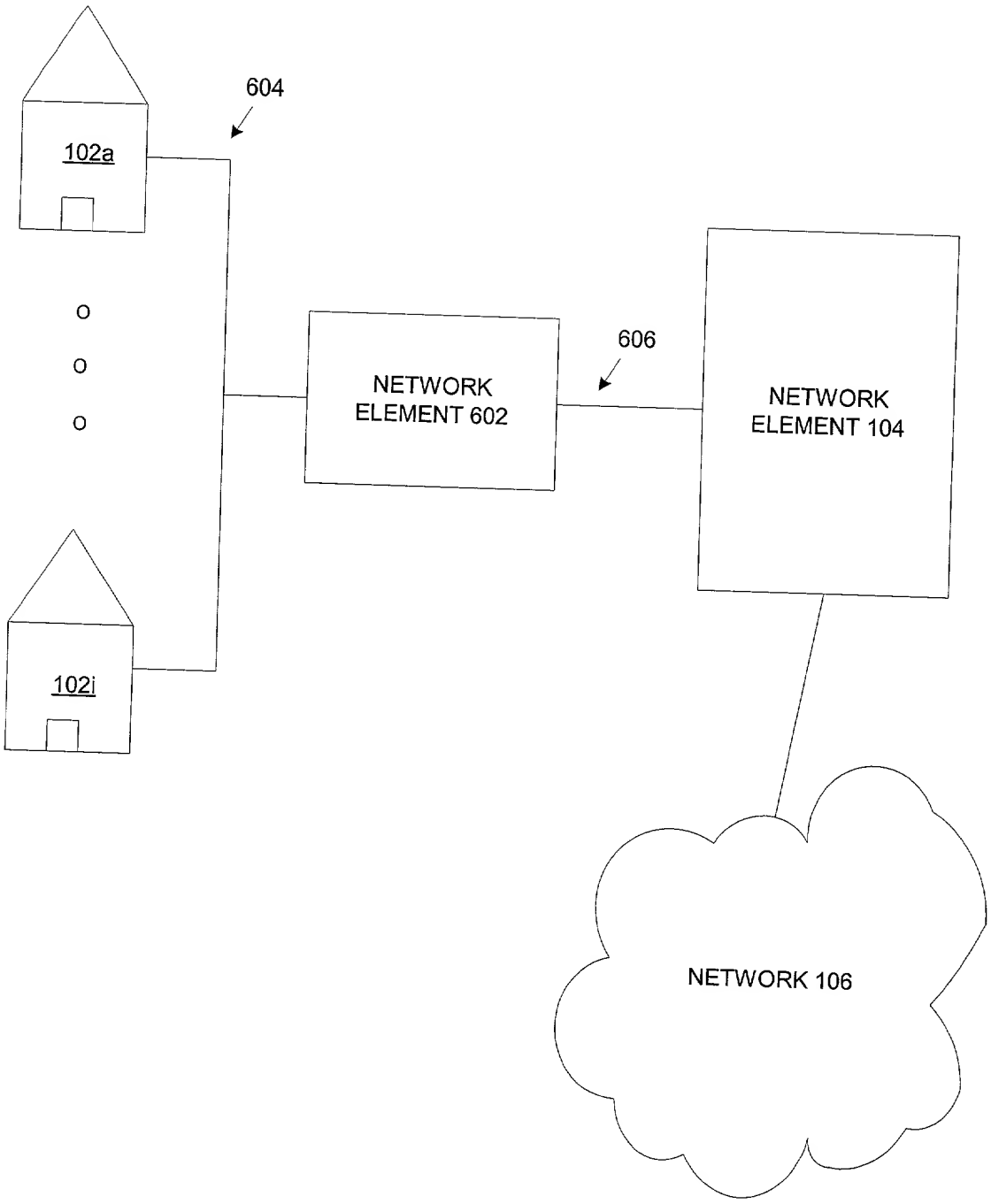
604
102a
o
o
o
102i
NETWORK
ELEMENT 602
606
NETWORK
ELEMENT 104
NETWORK 106

FIG. 6

DECLARATION AND POWER OF ATTORNEY FOR PATENT APPLICATION

As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below, next to my name.

I believe I am the original, first, and sole inventor (if only one name is listed below) or an original, first, and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled

METHOD AND APPARATUS FOR COMBINING PACKETS HAVING DIFFERENT PROTOCOL ENCAPSULATIONS WITHIN A CIRCUIT

the specification of which

_x_ is attached hereto.
___ was filed on_____ as
____ United States Application Number _____
____ or PCT International Application Number_____
____ and was amended on_____.
(if applicable)

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claim(s), as amended by any amendment referred to above. I do not know and do not believe that the claimed invention was ever known or used in the United States of America before my invention thereof, or patented or described in any printed publication in any country before my invention thereof or more than one year prior to this application, that the same was not in public use or on sale in the United States of America more than one year prior to this application, and that the invention has not been patented or made the subject of an inventor's certificate issued before the date of this application in any country foreign to the United States of America on an application filed by me or my legal representatives or assigns more than twelve months (for a utility patent application) or six months (for a design patent application) prior to this application.

I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, Section 119(a)-(d), of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

Prior Foreign Application(s)			Priority Claimed	
(Number)	(Country)	(Foreign Filing Date)	Yes	No
(Number)	(Country)	(Foreign Filing Date)	Yes	No
(Number)	(Country)	(Foreign Filing Date)	Yes	No

I hereby claim the benefit under Title 35, United States Code, Section 119(e) of any United States provisional application(s) listed below:

Application Number	(Filing Date)
Application Number	(Filing Date)

I hereby claim the benefit under Title 35, United States Code, Section 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by the first paragraph of Title 35, United States Code, Section 112, I acknowledge the duty to disclose all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, Section 1.56 which became available between the filing date of the prior application and the national or PCT international filing date of this application:

Application Number	Filing Date	Status -- patented, pending, abandoned
Application Number	Filing Date	Status -- patented, pending, abandoned

I hereby appoint the persons listed on Appendix A hereto (which is incorporated by reference and a part of this document) as my respective patent attorneys and patent agents, with full power of substitution and revocation, to prosecute this application and to transact all business in the Patent and Trademark Office connected herewith.

Send correspondence to Gregg A. Peacock, Reg. No. 45,001, BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP, 12400 Wilshire Boulevard 7th Floor, Los Angeles, California 90025 and direct telephone calls to Gregg A. Peacock, Reg. No. 45,001, (512) 330-0844.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full Name of Sole/First Inventor David Carrel

Inventor's Signature _____ Date _____

Residence San Francisco, California Citizenship USA
(City, State) (Country)

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APPENDIX A

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APPENDIX B

Title 37, Code of Federal Regulations, Section 1.56
Duty to Disclose Information Material to Patentability

(a) A patent by its very nature is affected with a public interest. The public interest is best served, and the most effective patent examination occurs when, at the time an application is being examined, the Office is aware of and evaluates the teachings of all information material to patentability. Each individual associated with the filing and prosecution of a patent application has a duty of candor and good faith in dealing with the Office, which includes a duty to disclose to the Office all information known to that individual to be material to patentability as defined in this section. The duty to disclosure information exists with respect to each pending claim until the claim is cancelled or withdrawn from consideration, or the application becomes abandoned. Information material to the patentability of a claim that is cancelled or withdrawn from consideration need not be submitted if the information is not material to the patentability of any claim remaining under consideration in the application. There is no duty to submit information which is not material to the patentability of any existing claim. The duty to disclosure all information known to be material to patentability is deemed to be satisfied if all information known to be material to patentability of any claim issued in a patent was cited by the Office or submitted to the Office in the manner prescribed by §§1.97(b)-(d) and 1.98. However, no patent will be granted on an application in connection with which fraud on the Office was practiced or attempted or the duty of disclosure was violated through bad faith or intentional misconduct. The Office encourages applicants to carefully examine:

(1) Prior art cited in search reports of a foreign patent office in a counterpart application, and

(2) The closest information over which individuals associated with the filing or prosecution of a patent application believe any pending claim patentably defines, to make sure that any material information contained therein is disclosed to the Office.

(b) Under this section, information is material to patentability when it is not cumulative to information already of record or being made or record in the application, and

(1) It establishes, by itself or in combination with other information, a prima facie case of unpatentability of a claim; or

(2) It refutes, or is inconsistent with, a position the applicant takes in:

(i) Opposing an argument of unpatentability relied on by the Office, or

(ii) Asserting an argument of patentability.

A prima facie case of unpatentability is established when the information compels a conclusion that a claim is unpatentable under the preponderance of evidence, burden-of-proof standard, giving each term in the claim its broadest reasonable construction consistent with the specification, and before any consideration is given to evidence which may be submitted in an attempt to establish a contrary conclusion of patentability.

(c) Individuals associated with the filing or prosecution of a patent application within the meaning of this section are:

(1) Each inventor named in the application;

(2) Each attorney or agent who prepares or prosecutes the application; and

(3) Every other person who is substantively involved in the preparation or prosecution of the application and who is associated with the inventor, with the assignee or with anyone to whom there is an obligation to assign the application.

(d) Individuals other than the attorney, agent or inventor may comply with this section by disclosing information to the attorney, agent, or inventor.